P6.26 Two oil tanks are connected by two 9-m-long pipes, as in Fig. P6.26. Pipe 1 is 5 cm in diameter and is 6 m higher than pipe 2. It is found that the flow rate in pipe 2 is twice as large as the flow in pipe 1. (*a*) What is the diameter of pipe 2? (*b*) Are both pipe flows laminar? (*c*) What is the flow rate in pipe 2 (m^3/s)? Neglect minor losses.

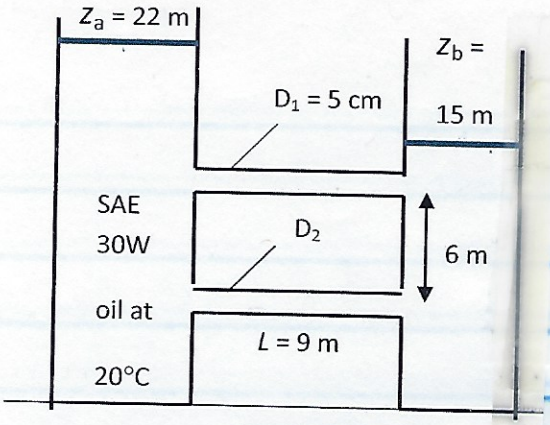

Fig. P6.26

(a) Consider energy equation from z_a to z_b through D_1 & D_2

$$\Delta z = z_a - z_b = h_{L_1} = h_{L_2} = 22 - 15 = 7$$

$$f_1 \frac{L}{D_1} \frac{V_1^2}{2g} = f_2 \frac{L}{D_2} \frac{V_2^2}{2g}$$

$$Q_2 = 2Q_1$$

$$V_2 D_2^2 = 2 V_1 D_1^2$$

$$V_2 = 2 V_1 (D_1/D_2)^2$$

$$f = 64/Re = \frac{64\nu}{VD}$$

$$\frac{64\nu}{V_1 D_1} \times \frac{L}{D_1} \times \frac{V_1^2}{2g} = \frac{64\nu}{2 V_1 D_1^2 D_2} \times \frac{L}{D_2} \frac{4V_1^2}{2g} \left(\frac{D_1}{D_2}\right)^4$$

$$\frac{V_1}{D_1^2} = \frac{2V_1}{D_2^2} \times \left(\frac{D_1}{D_2}\right)^4$$

$$2 = \frac{D_2^4}{D_1^4}$$

$$D_2 = 2^{1/4} D_1 \quad (2^{1/4} = 1.1892)$$

$$= 5.95 \text{ cm}$$

(b) $f = \frac{64\nu}{V_1 D_1} \times \frac{L}{D_1} \times \frac{V_1^2}{2g}$

$= \frac{64\nu L}{D_1^2 2g} \times V_1$

$V_1 = \frac{f \times D_1^2 g}{32 \nu L} = \frac{f \times .05^2 \times 9.81}{32 \times \frac{.29}{891} \times 9} = \frac{.172}{.094} = 1.83 \frac{m}{s}$

$\frac{.29}{891} = .00033$

$Q_1 = V_1 \frac{\pi D_1^2}{4} = .0036 \frac{m^3}{s}$

(c) $Q_2 = .0072 \, m^3/s \quad V_2 = Q_2 / \frac{\pi D_2^2}{4} = 2.57 \, m/s$

$Re_1 = \frac{V_1 D_1}{\nu} = 277 \qquad Re_2 = \frac{V_2 D_2}{\nu} = 463$

is laminar!

$D_1 =$ $= 5.95$ cm